Pilot Testing of Mercury Oxidation Catalysts for Upstream of Wet FGD Systems

Quarterly Technical Progress Report

April 1, 2005 – June 30, 2005

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ABSTRACT

This document summarizes progress on Cooperative Agreement DE-FC26-04NT41992, "Pilot Testing of Mercury Oxidation Catalysts for Upstream of Wet FGD Systems," during the time-period April 1, 2005 through June 30, 2005. The objective of this project is to demonstrate at pilot scale the use of solid honeycomb catalysts to promote the oxidation of elemental mercury in the flue gas from coal combustion, and the use of a wet flue gas desulfurization (FGD) system downstream to remove the oxidized mercury at high efficiency. The project is being co-funded by the U.S. DOE National Energy Technology Laboratory, EPRI, Great River Energy (GRE), TXU Generation Company LP, the Southern Company, and Duke Energy. URS Group is the prime contractor.

The mercury control process under development uses catalyst materials applied to honeycomb substrates to promote the oxidation of elemental mercury in the flue gas from coal-fired power plants that have wet lime or limestone FGD systems. Oxidized mercury is removed in the wet FGD absorbers and leaves with the byproducts from the FGD system. The current project is testing previously identified catalyst materials at pilot scale and in a commercial form, to provide engineering data for future full-scale designs. The pilot-scale tests will continue for approximately 14 months or longer at each of two sites to provide longer-term catalyst life data.

Pilot-scale wet FGD tests are being conducted periodically at each site to confirm the ability to scrub the catalytically oxidized mercury at high efficiency. The pilot wet FGD system has also been used downstream of catalysts being tested as part of another cooperative agreement (DE-FC26-01NT41185).

This is the sixth reporting period for the subject Cooperative Agreement. During this period, project efforts primarily consisted of operating the catalyst pilot unit at the TXU Generation Company LP's Monticello Steam Electric Station, including conducting integrated wet FGD tests and an intensive flue gas characterization effort. The gas characterization effort included the Ontario Hydro Method for mercury SCEM relative accuracy, Method 26a for flue gas halogens, Method 29 for flue gas metals, and the Controlled Condensation System method for flue gas SO_3/sulfuric acid. Also during the quarter, the second pilot unit, to be installed at Georgia Power's Plant Yates was shipped from its previous test site in San Antonio to URS's Austin office so that minor repairs could be conducted. This Technical Progress Report presents catalyst activity results from the oxidation catalyst pilot unit at Monticello and available results from the flue gas characterization efforts.

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INTRODUCTION

This document is the quarterly Technical Progress Report for the project "Pilot Testing of Mercury Oxidation Catalysts for Upstream of Wet FGD Systems," for the time-period April 1 through June 30, 2005. The objective of this project is to demonstrate at pilot scale the use of solid honeycomb catalysts to promote the oxidation of elemental mercury in the flue gas from coal combustion, and the use of a wet flue gas desulfurization (FGD) system downstream to remove the oxidized mercury at high efficiency. The project is being co-funded by the U.S. DOE National Energy Technology Laboratory, EPRI, Great River Energy (GRE), TXU Generation Company LP (TXU Generation), Southern Company, and Duke Energy. URS Group is the prime contractor.

The mercury control process under development uses catalyst materials in honeycomb form to promote the oxidation of elemental mercury in the flue gas from coal-fired power plants that have wet lime or limestone FGD systems. Oxidized mercury is removed in the wet FGD absorbers and leaves with the byproducts from the FGD system. The current project is testing previously identified catalyst materials at pilot scale and in a commercial form, to provide engineering data for future full-scale designs. The pilot-scale tests will continue for approximately 14 months or longer at each of two sites, to provide catalyst life data.

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Four utility team members are providing project host sites for mercury oxidation catalyst testing. GRE provided a test site at their Coal Creek Station (CCS), which fires North Dakota lignite, and City Public Service of San Antonio (CPS) is providing a test site at their J.K. Spruce Plant, which fires Powder River Basin (PRB) subbituminous coal. Both the CCS and Spruce mercury oxidation catalyst pilot tests have been conducted as part of project 41185. Both have hosted pilot FGD tests downstream of the catalysts as part of the current, 41992 project.

In the current project, TXU Generation is hosting pilot catalyst tests and intermittent wet FGD pilot tests at their Monticello Steam Electric Station, Unit 3, which fires a Texas lignite/Power River Basin (PRB) coal blend. The TXU Generation test program began during the previous quarter, in mid-January.

Duke Energy was also to host oxidation catalyst pilot and wet FGD pilot tests at one of their sites firing low-sulfur Eastern bituminous coal. However, both of their candidate sites (that are having wet FGD retrofitted but not selective catalytic reduction) were measured to have low elemental mercury concentrations in the flue gas downstream of the particulate control device. Consequently, Duke Energy decided not to host oxidation catalyst pilot tests. However, they did host pilot wet FGD tests to determine the ability to scrub the highly oxidized mercury content of the particulate control outlet flue gas at their Marshall Station.

Southern Company has a number of generating units that fire low-sulfur Eastern bituminous coal. They have agreed to host oxidation catalyst tests at their Georgia Power Plant Yates, Unit 1, and to provide project co-funding. Oxidation catalyst pilot tests will commence there during the third quarter of calendar year 2005.

The remainder of this report presents results from this project for the second quarter of calendar year 2005. The report is divided into five sections: an Executive Summary followed by a section that describes Experimental procedures, then sections for Results and Discussion, Conclusions, and References.

EXECUTIVE SUMMARY

Summary of Progress

The current reporting period, April 1 through June 30, 2005, is the sixth technical progress report period for the project. During the current period, the oxidation catalyst pilot unit continued in operation at Monticello Unit 3. In April, the wet FGD pilot unit was operated for two days downstream of each of the four catalysts being tested at Monticello. At the same time, Ontario Hydro measurements were made at the catalyst pilot unit inlet, catalyst outlet, and FGD outlet to measure relative accuracy for the mercury SCEMs used to quantify catalyst performance and mercury removal across the pilot wet FGD. Other gas characterization measurements were made, including catalyst inlet halogen, SO_3 and metals concentrations, and catalyst outlet SO_3 concentrations. Also during the quarter, the second pilot unit, to be installed at Georgia Power's Plant Yates was shipped from its previous test site in San Antonio to URS's Austin office so that minor repairs could be completed.

Problems Encountered

There were no significant problems encountered during the current reporting period other than technical issues that are discussed later in this report.

Plans for Next Reporting Period

During the next reporting period (July 1 through September 30, 2005), catalysts will be evaluated for elemental mercury oxidation activity at Monticello through routine (~bimonthly) evaluation trips. Minor repairs and upgrades will be completed on the second oxidation catalyst pilot unit, and that pilot unit will be shipped to Plant Yates and installed there during the quarter.

Prospects for Future Progress

During the subsequent reporting period (October 1 through December 31, 2005), catalysts will be evaluated for elemental mercury oxidation activity at Monticello through routine (~bimonthly) evaluation trips. The oxidation catalyst pilot unit at Plant Yates should be in operation and also be evaluated for elemental mercury oxidation activity through routine evaluation trips. Intensive gas characterization efforts and initial wet FGD pilot testing will likely occur at Plant Yates during the quarter.

EXPERIMENTAL

The work being conducted as part of this project will use three different experimental apparatus types. One is an elemental mercury catalyst oxidation pilot unit (8000 acfm of flue gas treated), the first of which was recently installed at TXU Generation's Monticello Steam Electric Station. A second, nearly identical pilot unit was previously located at CPS' Spruce Plant. During the course of this project, this second pilot unit will be relocated and installed at Georgia Power's Plant Yates.

Each pilot unit has four separate compartments that allow four different catalysts to treat flue gas from downstream of the host plant's particulate control device. Details of the pilot unit design, construction, catalyst preparation and pilot unit operation have been discussed in previous quarterly technical progress reports as part of the ongoing 41185 project[1,2,3,4]. The activity of these catalysts is determined by measuring the change in elemental mercury concentration across each catalyst, while ensuring that the total mercury concentrations do not change significantly across the catalyst. These measurements are primarily conducted using a mercury semi-continuous emissions monitor (SCEM) developed with funding from EPRI. The analyzer has been described in a previous report[5]. Periodically, the analyzer results are verified by conducting manual flue gas sampling efforts in parallel across each catalyst chamber by the Ontario Hydro method.

The second experimental apparatus is a bench-scale test unit that is used to evaluate the activity of candidate catalyst samples under simulated flue gas conditions. The bench-scale catalyst oxidation test apparatus was previously described in quarterly technical progress reports for the 41185 project[3,4].

The third experimental apparatus is a pilot-scale wet FGD unit that is being designed and fabricated as part of the current, 41992 project, to allow the measurement of how effectively catalytically oxidized mercury can be scrubbed. The pilot unit was designed to treat the flue gas from one of four catalyst chambers on either of the mercury oxidation catalyst pilot units. The design basis and a simplified piping and instrumentation diagram (P&ID) for the pilot wet FGD system were included in a previous technical progress report for this project.[6]

RESULTS AND DISCUSSION

This section provides details of technical results available from the current reporting period, April 1 through June 30, 2005. Presented are activity results for the catalyst materials installed in the catalyst pilot unit at Monticello, results from pilot wet FGD tests conducted downstream of each of the catalysts at Monticello, and results from flue gas characterization measurements made at Monticello. No results are available yet from the pilot unit that will be moved from Spruce Plant to Plant Yates.

Catalyst Pilot Unit Operation at Monticello

The catalyst pilot unit was started up in flue gas service at Monticello Steam Electric Station, near Mount Pleasant, Texas, on January 14, 2005, and has operated continuously since then other than during short, unscheduled host unit outages. The physical characteristics of the four catalysts currently installed are summarized in Table 1.

Table 1. Characteristics of Catalysts Installed in Pilot Unit at Monticello

Catalyst Box Number	Catalyst	Cross Section, in x in (m x m)	Catalyst Depth	Cell Pitch, mm	Cells per Sq. In. (CPSI)	Area Velocity, std. ft/hr
1	Pd #1 (Johnson Matthey)	29.5 x 29.5 (0.75 x 0.75)	9 in. (0.23 m)	3.2	64	52
2	SCR (Cormetech/MHI)	35.4 x 36.2 (0.90 x 0.92)	29.5 in. (0.75 m)	3.3	58	11
3	Gold (Sud-Chemie Prototech)	29.5 x 29.5 (0.75 x 0.75)	3 x 3 in. (3 x 0.08 m)	3.2	64	52
4	Pd #1 (regenerated from CCS)	29.5 x 29.5 (0.75 x 0.75)	3 x 3 in. (3 x 0.08 m)	3.2	64	52

Catalyst Pressure Drop Performance

In previous catalyst testing at CCS, fly ash was observed to build up in the horizontal-gas-flow catalyst cells, resulting in increased catalyst pressure drop and lowered catalyst oxidation performance. Sonic horns were installed and were generally effective in preventing fly ash buildup. Since Monticello, like CCS, has an ESP for particulate control (Spruce has a reverse-gas fabric filter), it was expected that the sonic horns would be necessary to prevent fly ash buildup there.

The sonic horns were placed in service on the catalyst pilot unit at the end of January, two weeks after initial startup on January 14, 2005. However, the sonic horns did not operate properly through the remainder of that quarter. During that period, a failed compressed air pipe nipple was

replaced, the horn timer was replaced, the solenoid valves controlling air flow to the horns were replaced, the horns were disassembled and cleaned, and an air pressure regulator was installed to ensure that the optimum air pressure of 70 psig was supplied to the horns. While these efforts corrected a number of operational issues, it still remained that the solenoid valves controlling air flow to the horns did not turn off properly at the end of their cycle (the horns are intended to sound 10 seconds each every half hour).

In April, one solenoid valve that had been particularly problematic was replaced with a larger valve (3/4-inch vs. ¼-inch) installed upstream of the horn rather than downstream (on the air exhaust from the horn). This change, along with minor wiring and tubing changes, resulted in all four valves cycling properly beginning in late April. The four horns appear to have cycled properly through the remainder of the quarter.

Two other issues confound the pressure drop data for the oxidation catalysts. One is that the ID fan differential available at Monticello is not as great as at CCS or Spruce, which means that the catalyst pilot only achieves full flue gas flow when Unit 3 is at or near full load. When the unit is at reduced load, the flow rates to the oxidation catalysts also decrease. While this does a good job of simulating the effects of load changes on the oxidation catalysts, it does not always allow for extended periods of operation at controlled gas flow rates to observe catalyst pressure drop.

The other issue was that the total pressure and differential pressure transducers for the flow meter for Catalyst 1 (Johnson Matthey Pd #1) did not operate properly when the pilot unit was started up on January 14. At the end of January, the failed components were exchanged with those from Catalyst 4 (regenerated Pd #1 from CCS) since it was thought to be more important to measure and control the flue gas flow rate through the new catalyst rather than the regenerated one.

The total pressure transducer was determined to have failed and was replaced, while the differential pressure transducer appeared only to have lost its calibration and was recalibrated. The failed transducer had a delivery time of six weeks, so it was late March before the new and recalibrated components were re-installed.

In spite of these efforts, the flow rate measurement for the regenerated Pd catalyst remained inaccurate. In April, it was determined that the pressure differential transducer was not properly zeroed, and that one engineering unit conversion factor was mistakenly entered as a positive rather than a negative value when the transducer was recalibrated. Now that these problems have been corrected, the transducer appears to be operating properly.

Figure 1 shows the “full load” pressure drop data for all four catalysts from start up through the end of the quarter. “Full load” was defined as periods where the flue gas flow rate through the highest-flowing catalyst (gold) was at least 1900 acfm. The desired flow rate is 2000 acfm for all four catalysts.

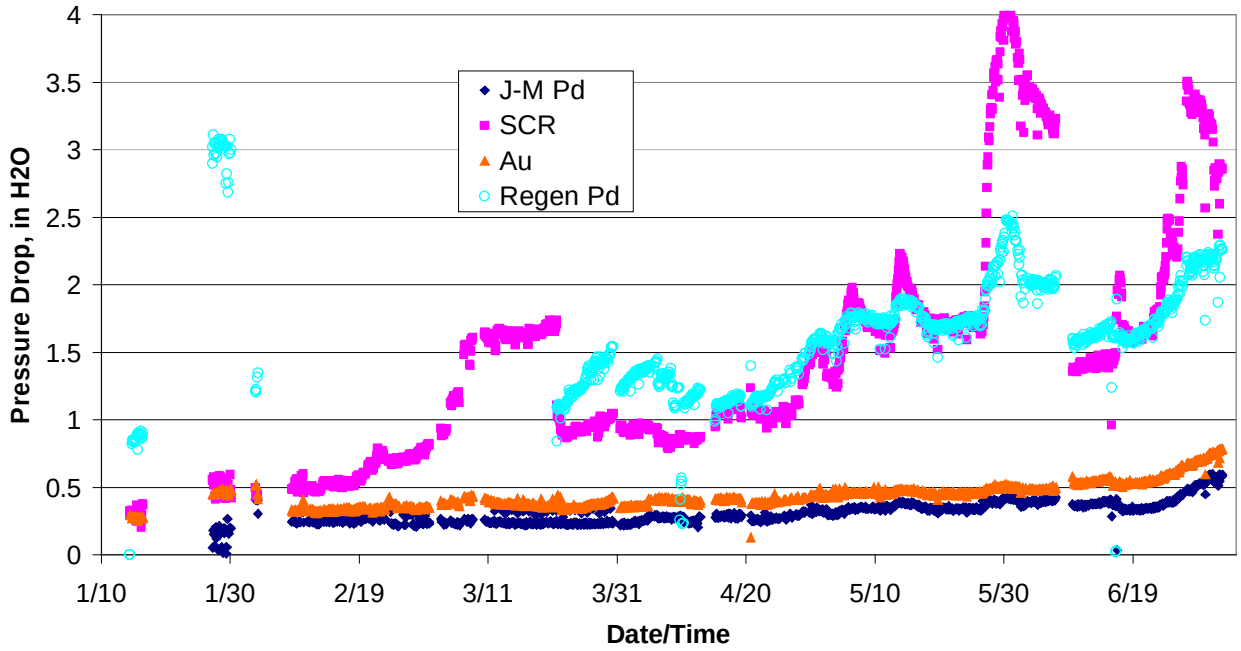

Figure 1. Full-load Catalyst Pressure Drop Data from Monticello Pilot Unit

The data show that the pressure drop across the Johnson-Matthey Pd and gold catalysts remain low (about 0.5 in. H_2O) while the SCR and regenerated Pd catalysts show excursions to higher pressure drop.

During the previous quarter, some of the excursions where the pressure drop across the SCR and regenerated Pd catalysts increased appeared to correspond with periods where the sonic horns were not operating properly. This does not appear to be the case during the current quarter. As an example, there was a sharp increase in pressure drop around May 25, but the sonic horns were observed to be operating properly the next time project team members were on site in mid-June. The pressure drop across these two catalysts appeared to recover briefly following a short outage of the host unit, but increased sharply again in late June. The pressure drop across the gold and Johnson Matthey Pd catalyst also increased at the end of June, for reasons that are not yet determined.

It is possible that improperly functioning horns during the first quarter of operation led to fly ash buildup in the SCR and regenerated Pd catalysts, that have not been removed during the current operation with fully functional horns. The SCR catalyst may be more sensitive to horn operation because of its greater catalyst length than the others, and the regenerated Pd may be more sensitive because of residual fly ash remaining on the catalyst surfaces from its 20+ months of service at CCS. It is possible that these two catalysts will have to be shut down and cleaned if their pressure drops continue to see high excursions.

Elemental Mercury Oxidation Activity Performance

The activity of these four catalysts for oxidizing elemental mercury was measured twice during the quarter. The first measurement trip was in early April, coincident with pilot wet FGD tests conducted downstream of each catalyst. However, an unscheduled unit outage delayed the completion of this testing until the week of April 18. The results of the activity measurements made in April are summarized in Table 2. The pilot wet FGD system was operated for two days downstream of each catalyst, so average elemental mercury oxidation data are shown for two days for each catalyst in the table.

Table 2. Results of Catalyst Activity Measurements at Monticello, April 2005 (all values represent daily averages)

Sample Location (Sampling Date)	Hg Concentration, μg/Nm^3 @ 3% O_2*				Total Hg % Oxidation		% Hg Adsorption Across Catalyst	% Hg Oxidation Across Catalyst
	Catalyst Inlet		Catalyst Outlet					
	Total Hg	Elemental Hg	Total Hg	Elemental Hg	Catalyst Inlet	Catalyst Outlet		
SCR (4/6)	30.8	21.3	30.6	9.9	31	68	1	54
SCR (4/7)	29.7	15.5	23.1	11.0	48	52	22	29
Regenerated Pd #1 (4/8)	29.2	20.1	22.0	7.8	31	64	25	61
Regenerated Pd #1 (4/9)	32.9	21.5	31.6	5.0	35	84	4	77
J-M Pd #1 (4/10)	30.3	17.1	22.7	7.6	44	67	25	55
J-M Pd #1 (4/18)	28.6	13.4	28.8	7.9	53	73	-1	41
Gold (4/19)	34.3	13.9	30.7	1.22	59	96	11	91
Gold (4/20)	33.3	21.4	31.7	1.50	36	95	5	93

*1 μg/Nm^3 @ 3% O_2 = 0.67 lb Hg/10^{12} Btu heat input

Before these results are discussed, it should be noted that wet FGD tests were also being conducted at the same time these measurements were made. Although two mercury SCEMs were used to support these measurements, one SCEM was used to monitor the catalyst inlet and outlet locations while the second was used to monitor the FGD outlet. The first monitor was cycled to collect mercury oxidation values and to collect FGD inlet concentration data for quantifying FGD mercury removal performance. This second objective meant that the SCEM cycling between inlet and outlet sample locations and between quantifying elemental versus total mercury concentrations was not always optimal for determining catalyst mercury breakthrough and elemental mercury oxidation percentages. Furthermore, because the Monticello Unit 3 boiler fires a blend of PRB and Texas lignite, the total mercury concentration and mercury oxidation at the ESP outlet (catalyst inlet) location can vary significantly with time. Evidence if this variability is seen in the average percent mercury oxidation in the catalyst inlet flue gas, which varied over a wide range over these measurement days, from 31% to 59%. These two effects led to significant scatter in the comparisons of total mercury and elemental mercury concentrations as shown in the table, which represent arithmetic averages of all valid data points collected during the measurement day.

The last two columns in the table, the percentage total mercury adsorption observed across the catalyst and the percentage elemental mercury oxidation across the catalyst, vary significantly from day to day for all but the gold catalyst. It is believed that this variability is due to uncertainty in quantifying the averages shown rather than variations in actual catalyst performance. For the gold catalyst, the relatively low apparent total mercury adsorption shown in the table is most likely due to a more stable lignite/PRB blend percentage during these measurements than on the previous days. The good agreement seen between the daily percent oxidation values seen for the gold is also likely due to a more stable fuel blend, and the fact that the gold was measured to be the most active catalyst (i.e., inlet mercury concentrations have less effect on the calculated oxidation percentage when the actual percentage is greater than 90%).

The results show the gold catalyst to be the most active, with 91% to 93% oxidation seen on the two measurement days. These values are identical to the percentages measured on two days in early March. The regenerated palladium was the next most active, with 61% to 77% oxidation measured for the two days. The performance of the regenerated palladium was significantly better than that of the fresh material from Johnson Matthey, which showed 41% to 55% oxidation. The SCR catalyst was apparently somewhat less active than the Johnson Matthey palladium, showing 29% to 54% oxidation.

The difference between the apparent activity of the regenerated palladium and the fresher, Johnson Matthey palladium may be partially due to the different geometries of the two. The regenerated palladium is installed as three 3-inch layers, while the Johnson Matthey palladium is installed as a single 9-inch layer. While the latter is advantageous with respect to ease of installation, particularly for future full-scale installations, it is disadvantageous for mass transfer (diffusion of mercury to the catalyst geometric surface and into the catalyst pores to be oxidized). These catalysts operate with laminar flow within each cell, which is less desirable than turbulent flow for mass transfer. Between each layer, the flow is turbulent because the effective diameter of the flow channel is hundreds of times that of an individual cell. The resulting mixing between layers can improve overall mass transfer. URS is currently developing a laminar flow diffusion model that can be used to quantify the expected performance difference between three 3-inch layers and one 9-inch layer.

Catalyst oxidation performance was measured a second time during the quarter, June 15-17, 2005. These results are summarized in Table 3.

Table 3. Results of Catalyst Activity Measurements at Monticello, June 2005

Sample Location	Hg Concentration, mg/Nm^3 @ 3% O_2*				Total Hg % Oxidation		% Hg Adsorption Across Catalyst	% Hg Oxidation Across Catalyst
	Catalyst Inlet		Catalyst Outlet					
	Total Hg	Elemental Hg	Total Hg	Elemental Hg	Catalyst Inlet	Catalyst Outlet		
Measurements on June 16, 2005								
J-M Pd #1	22.6	10.1	24.6	5.4	56	78	-9	46
SCR	35.8	15.4	34.1	10.6	57	69	5	31
Regen. Pd	35.2	14.7	36.9	5.7	58	84	-5	61
Measurements on June 17, 2005								
Gold	34.8	12.9	36.2	2.0	63	94	-4	84

*1 μg/Nm^3 @3% O_2 = 0.67 lb Hg/10^{12} Btu heat input

The apparent oxidation across all four catalysts dropped from April to June, indicating a loss of activity with time in service in this flue gas. The gold dropped from greater than 90% to 84% oxidation, while the SCR catalyst dropped from as high as 54% in April down to 31% in June. The performance of the SCR catalyst, and possibly the regenerated palladium, may have been adversely affected by fly ash buildup, as indicated by the pressure drop across these two catalyst beds. This issue was discussed above in this report. The Johnson Matthey palladium and gold were apparently relatively clean, as evidenced by the pressure drop values of approximately 0.5 in. H_2O or less for these two catalysts, and were less likely to have been impacted by fly ash buildup.

The activity data for these catalysts are plotted versus time in Figure 2. The figure is illustrated to show linear trends for activity loss versus time for each of the four catalyst types, extrapolated back to the time they were initially placed in operation. However, there is quite a bit of scatter for the data for all but the gold catalyst. More time in service will determine whether the linear correlations shown in the figure are proven true.

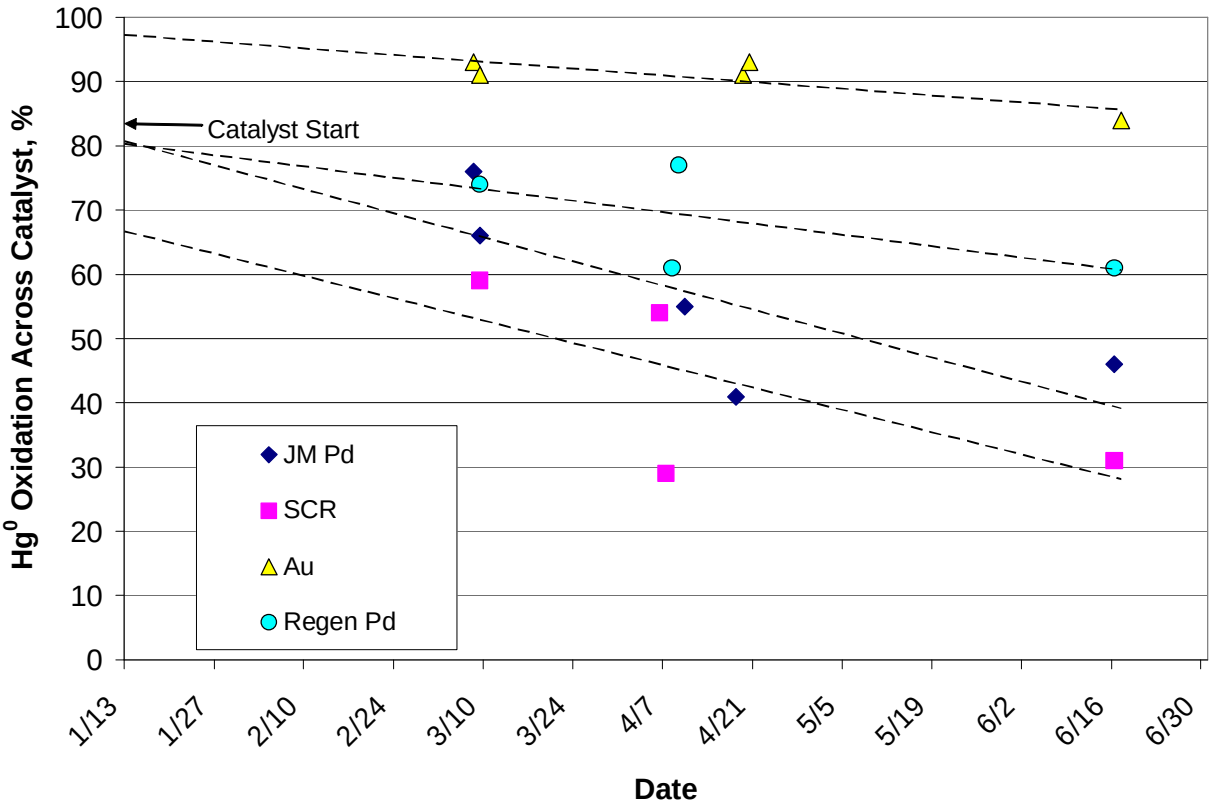

Figure 2. Elemental Mercury Oxidation Activity versus Time for Catalysts at Monticello

Wet FGD Pilot Tests at Monticello

As mentioned above, the pilot wet FGD system was operated at Monticello in April for two days downstream of each catalyst. A baseline test (no catalyst upstream of the FGD system) was also conducted. The results of these tests are summarized in Table 4 below.

Table 4. Results of Pilot Wet FGD Tests Conducted Downstream of Oxidation Catalysts at Monticello, April 2005

Sample Location (Sampling Date)	Hg Concentration, mg/Nm^3 @ 3% O_2*				Total Hg % Oxidation@ Catalyst Outlet	Total Hg Removal Across Wet FGD, %	Hg^0 Removal Across Wet FGD, %	Hg^{+2} Removal Across Wet FGD, %
	Catalyst Outlet/FGD Inlet**		Wet FGD Outlet					
	Total Hg	Elemental Hg	Total Hg	Elemental Hg				
Baseline [no catalyst] (4/5)	22.4	13.9	12.1	9.9	38	46	29	74
SCR (4/6)	30.6	9.9	8.1	8.9	68	74	10	104
SCR (4/7)	23.1	11.0	6.4	4.5	52	72	59	85
Regenerated Pd #1 (4/8)	22.0	7.8	4.2	2.5	64	81	69	88
Regenerated Pd #1 (4/9)	31.6	5.0	8.6	3.4	84	73	31	81
J-M Pd #1 (4/10)	22.7	7.6	11.4	3.9	67	50	48	51
J-M Pd #1 (4/18)	28.8	7.9	4.6	2.4	73	84	70	89
Gold (4/19)	30.7	1.22	5.2	3.1	96	83	-150	93
Gold (4/20)	31.7	1.50	7.7	2.1	95	76**	-43	81**

*1 μg/Nm^3 @3% O_2 = 0.67 lb Hg/10^{12} Btu heat input
**Value is believed to be biased low by FGD recycle pump cavitation

There are several things to note in the data presented in the table. One is that for a number of the tests, significant elemental mercury removal percentages are seen (29 to 70%). This is not an expected result, as elemental mercury is not water soluble and would not be expected to be removed at a significant percentage in an aqueous-based wet absorber. In some instances, this appears to be due to a measurement bias in the FGD outlet speciation. For example, in the baseline (no catalyst upstream) test, the elemental mercury removal percentage was measured at 29%, while the oxidized mercury removal was measured at 74%. One would expect oxidized mercury to be removed at a higher percentage in an efficient wet FGD absorber (SO_2 removal performance was maintained at 90% or greater across the absorber). These two data points suggest that elemental mercury was being oxidized in the sample delivery system for the FGD outlet SCEM, biasing the outlet elemental mercury concentration low and the outlet oxidized mercury concentration (total minus elemental) high.

However, the FGD outlet total mercury concentration data suggest that some elemental mercury was being removed. If only oxidized mercury were removed by the wet FGD, the total mercury removal percentage measured should be no greater than the mercury oxidation percentage at the

FGD inlet. For the baseline test, the FGD inlet mercury oxidation percentage was 38%, while the total mercury removal across the wet FGD absorber was higher at 46%. Four other days' data show the same effect, where the FGD total mercury removal percentage was greater than the FGD inlet mercury oxidation (4/6 and 4/7, SCR catalyst; 4/8, regenerated Pd catalyst; and 4/18, Johnson Matthey Pd catalyst). The remaining four days' data show the expected trend, where the total mercury removal percentage across the FGD is lower than the FGD inlet oxidation percentage.

Ontario Hydro Method measurements were made in concert with these tests (for the second test day downstream of each catalyst only), to provide a measure of SCEM relative accuracy. These results are discussed later in this report, and provide additional information about mercury capture across the wet FGD absorber.

Another thing to note about these SCEM results is that the mercury capture by the wet FGD system downstream of the gold catalyst was limited by the phenomenon called "re-emissions," where a portion of the oxidized mercury captured by the wet FGD absorber is reduced by sulfite ion in the FGD liquor to form elemental mercury. This elemental mercury is then stripped from the FGD liquor and re-enters the flue gas. Evidence of re-emissions is seen when the FGD outlet elemental mercury concentrations are larger than the inlet elemental mercury concentrations. Significant re-emissions levels are typically not seen under forced oxidation conditions, where sulfite ion concentrations are controlled to very low levels in the FGD liquor. These wet FGD pilot tests were conducted in forced oxidation mode, and the sulfite concentrations were generally below detectable levels. Furthermore, the oxidation/reduction potential (ORP) was measured during the latter tests, and measurements showed an ORP of greater than 600 mV, which is indicative of highly oxidizing conditions that should minimize re-emissions. Yet, in the gold catalyst tests, significant re-emissions levels were measured, as shown in the table. As discussed later in this report, the Ontario Hydro method results show evidence of re-emissions from other catalyst tests.

It should also be noted in the second day of the gold catalyst test that the oxidized mercury removal was most likely biased low for much of the measurement day by cavitation of the absorber recycle pump, which significantly lowered the liquid to gas ratio (L/G). This cavitation was an inadvertent effect of a decision to maintain the absorber reaction tank at a minimum level during this test, which was run overnight in an attempt to approach steady state in the reaction tank slurry (the other tests were run approximately 10 hours per day, during daylight hours only). While attempting to maintain a minimum level, net evaporation of water from the absorber in excess of liquid makeup lowered the absorber reaction tank level to the point where the recycle pump suction was no longer flooded, leading to cavitation. It was several hours into the daytime operation on the second day, during which time the SCEM data were collected, before this problem was corrected by adding service water to raise the slurry level in the tank.

Notwithstanding these issues, it was apparent that having the oxidation catalysts upstream increased the pilot wet FGD mercury capture percentage from 46% up to 72% to 84% for seven of the eight days of operation downstream of catalysts. The gold catalyst was clearly the most active for elemental mercury oxidation, yet the mercury removal percentage for the gold catalyst test days was no higher than was measured for one day each with the regenerated palladium and

Johnson Matthey palladium. Scrubber additives (e.g., TMT-15) to prevent elemental mercury re-emissions would likely improve the overall mercury capture with the gold catalyst upstream of the wet FGD absorber.

During the wet FGD pilot tests, samples were collected and preserved of the FGD recycle liquor and recycle slurry solids. The samples were analyzed for typical FGD species, and for mercury concentration. Also, coal and ash samples were collected. The coal samples were analyzed for mercury, chloride, fluoride, bromide and iodide concentrations, and the ash samples were analyzed for mercury content and loss on ignition (LOI). These analysis results are reported in Tables 5 through 10 below.

Table 5. FGD Liquor Major Species Analysis Results (mg/L)

Sample ID	SO_3	SO_4	Cl^-	Mg	Ca	Na	CO_3
Baseline [no catalyst] (4/5)	0	4,651	1,355	934	685	698	1.06
SCR (4/6)	0	5,035	1,440	1,092	640	773	1.27
SCR (4/7)	0	4,956	1,458	1,107	662	787	1.48
Regenerated Pd #1 (4/8)	0	4,489	1,178	898	650	652	1.06
Regenerated Pd #1 (4/9)	0	4,415	1,198	902	625	657	1.03
J-M Pd #1 (4/10)	0	4,484	1,205	889	640	650	1.04
J-M Pd #1 (4/18)	0	3,010	633	475	633	333	0.86
Gold (4/19)	0	3,240	729	547	613	404	0.83
Gold (4/20)	0	7,033	2,296	1,727	621	715	1.57
Full-scale Module 3C (4/20)	0	4,903	1,441	1,027	627	1,226	0.74

Table 6. FGD Slurry Solids Major Species Analysis Results

Sample ID	Slurry Wt% Solids	Solids Wt% Inerts	Solids Analysis, mg/g				
			Ca	Mg	SO_4	SO_3	CO_3
Baseline [no catalyst] (4/5)	7.41	1.53	227	0	540	0	4
SCR (4/6)	8.88	1.50	227	0	540	0	3
SCR (4/7)	10.24	1.52	231	0	538	0	2
Regenerated Pd #1 (4/8)	7.96	1.45	234	0	536	0	4
Regenerated Pd #1 (4/9)	9.06	1.53	227	0	546	0	2
J-M Pd #1 (4/10)	17.07	1.02	229	0	547	0	2
J-M Pd #1 (4/18)	5.33	0.84	233	0	535	0	7
Gold (4/19)	5.67	0.84	229	0	538	0	4
Gold (4/20)	10.58	1.99	230	0	540	0	1
Full-scale Module 3C (4/20)	7.99	0.97	234	0	549	0	7

Table 7. FGD Liquor Mercury Analysis Results

Sample ID	Measured Hg Concentration Range, µg/L	No. of Analyses
Baseline (4/5/05 17:00)	69-316	2
SCR Catalyst (4/7/05 09:30)	92-160	2
Regenerated Pd (4/9/05)	148-274	5
J-M Pd (4/18/05 16:55)	155-264	2
Gold (4/20/05)	151-474	2
Full-scale Module 3C (4/20/05)	162-468	3

Table 8. FGD Slurry Solids Mercury Analysis Results

Sample ID	Hg Concentration, µg/g
Baseline (4/5/05 17:00)	0.99
SCR Catalyst (4/7/05 09:30)	1.30
Regenerated Pd (4/9/05)	1.22
J-M Pd (4/18/05 16:55)	1.17
Gold (4/20/05)	4.96
Full-scale Module 3C (4/20/05)	0.44

Table 9. Monticello Coal Analysis Results

Sample ID	Hg, mg/g	Cl, mg/kg	F, mg/kg	Br, mg/kg	I, mg/kg
Unit 3 Lignite 3/8/05 12:40	0.399	95.1	73.5	<12	<25
Unit 3 PRB 3/8/05 14:20	0.093	26.3	42.6	<23	<27
Unit 3 Lignite 3/9/05 09:15	0.386	63.6	74.3	<12	<25
Unit 3 PRB 3/9/05 12:20	0.108	27.3	45.4	<25	<25
Unit 3 Lignite 4/5/2005 16:20	0.328	50.9	55.7	<12	<25
Unit 3 PRB 4/5/2005 16:00	0.107	16.7	39.7		
Unit 3 Lignite 4/6/2005 16:30	0.300	82.7	57.0	<12	<25
Unit 3 PRB 4/6/2005 15:15	0.113	19.4	40.3		
Unit 3 Lignite 4/7/2005 8:30	0.122	16.6	50.6	<13	<24
Unit 3 PRB 4/7/2005 10:05	0.099	10.3	39.3		
Unit 3 Lignite 4/8/2005 13:09	0.314	42.4	55.2	<5	
Unit 3 PRB 4/8/2005 11:41	0.133	20.9	40.3		
Unit 3 Lignite 4/9/2005 11:30	0.245	25.1	46.6	<12	<24
Unit 3 PRB 4/9/2005 11:38	0.244	15.5	41.9		
Unit 3 Lignite 4/18/2005 12:30	0.312	42.1	46.6	<12	<25
Unit 3 PRB 4/18/2005 11:30	0.092	29.0	56.8	<24	<26
Unit 3 Lignite 4/19/2005 8:00	0.329	54.0	56.8	<13	<24
Unit 3 PRB 4/19/2005 10:30	0.126	30.0	48.9	<25	<25
Unit 3 Lignite 4/20/2005 16:30	0.269	63.5	56.5	<13	<25
Unit 3 PRB 4/20/2005 16:00	0.083	20.7	44.5	<24	<26

Table 10. Monticello Unit 3 Ash Sample Analysis Results

Sample ID	LOI	Hg, µg/g
Unit 3 B5 3/8/05	-	0.13
Unit 3 B5 3/9/05	-	0.13
Unit 3 B-6 4/5/05 15:15	0.10	0.10
Unit 3 B-2 4/6/05 15:15	0.25	0.11
Unit 3 4/7/05	0.45	0.16
Unit 3 B-5 4/9/05 16:10	0.27	0.10
Unit 3 4B 4/18/05 11:15	0.42	0.14
Unit 3 1st Field Hopper B6 4/20/05 15:50	0.42	0.13
Unit 3 2nd Field Hopper B17 4/20/05 15:52	0.34	0.21

The results of the routine FGD sample analyses in Tables 5 and 6 show expected trends. The FGD liquor from all tests was highly oxidized, with no measurable sulfite ion content. Chloride ion concentrations were relatively low, ranging from approximately 1000 to 2000 ppm. The sample from the second day of the gold catalyst FGD test, which was run around the clock for greater than 30 hours, indicate that the reaction tank liquor became somewhat more concentrated in dissolved salts than the full-scale scrubber, with the sulfate, chloride, and magnesium ion concentrations being higher for this sample than in any of the other pilot-scale or the full-scale module samples. The solids samples from all of the catalyst pilot tests and in the full-scale module sample contained greater than 95% gypsum (calcium sulfate dehydrate) and indicated a high limestone utilization of 98% or greater.

The mercury analysis results in Tables 7 and 8 show some unexpected results. The liquid phase sample mercury concentration analyses proved to be difficult to conduct, even when using the method of standard additions to attempt to compensate for interferences within the sample matrix. There is apparently an interfering species in the FGD liquor from Monticello Unit 3 that prevents the accurate quantification of mercury concentrations. The samples were analyzed on several occasions at differing sample dilution levels, with different results for virtually every analysis. Because of these difficulties, the liquid phase mercury concentrations cannot be reported with certainty. However, it is clear that the liquid phase concentrations are relatively high, ranging from 92 to 470 µg/L for the catalyst test samples.

The solids phase results are also a bit surprising. The gypsum mercury concentration was about 1 µg/g for the baseline pilot FGD test, and only increased to about 1.2-1.3 µg/g for the first three catalyst tests. The mercury concentration increased markedly for the sample from the gold catalyst test, to nearly 5 µg/g. This is probably due to the fact that the gold catalyst test was run continuously for greater than 30 hours, whereas the other three catalyst tests were only run during day shift on two consecutive days (except for the J-M Pd catalyst test, which was split up due to a boiler outage). Thus, the gold catalyst test results probably better reflect steady-state operation with enhanced mercury capture downstream of the catalyst than the other three, shorter-term catalyst test results.

The FGD liquor and solids sample analysis results have been used to calculate what percentage of the mercury in the FGD slurry was found in the liquor versus the solid phase. These results are summarized in Table 11. They show that a high percentage of the mercury captured in the wet

FGD system was found in the liquor, particularly if the high end of the range of liquor mercury concentrations measured was accurate (with 45 to 92% found in the liquor). These values represent some of the highest percentage mercury capture in the liquid phase that URS has measured in FGD systems on U.S. coal-fired power plants.

Table 11. Summary of Mercury Partitioning Between the Liquor and Solids in FGD Slurry Samples from the April Monticello Tests

Sample ID	Slurry Wt% Solids	Liquor Hg Conc. Range, µg/L	Solids Hg Conc., µg/g	Hg in Liquor Based on Low Conc., µg/1000g slurry	Hg in Liquor Based on High Conc., µg/1000g slurry	Hg in Solids, µg/ 1000g slurry	% of Hg in Liquor Based on Low Conc.	% of Hg in Liquor Based on High Conc.
Baseline [no catalyst] (4/5)	7.41	69-316	0.99	64	293	73	47%	80%
SCR (4/7)	10.24	92-160	1.3	83	144	133	38%	52%
Regenerated Pd #1 (4/9)	9.06	148-274	1.22	135	249	111	55%	69%
J-M Pd #1 (4/18)	5.33	155-264	1.17	147	250	62	70%	80%
Gold (4/20)	10.58	151-474	4.96	135	424	525	20%	45%
Full-scale Module 3C (4/20)	7.99	162-468	0.44	149	431	35	81%	92%

The data in Table 11 were used to calculate the apparent mercury capture in the pilot wet FGD per gram of gypsum byproduct for the longer-term gold wet FGD test, taking into account the measured mercury in the gypsum (4.96 µg/g) and the corresponding mercury in the FGD liquor. It was not seen as being worthwhile to do these calculations for the other tests, as they were not run for long enough periods to come to steady state with respect to mercury content in the gypsum byproduct. The calculations for the gold catalyst test showed that the mercury in the FGD slurry sample represented 6.2 to 9.0 µg of mercury per gram of byproduct gypsum, based on the low and high measured concentrations of mercury in the FGD liquor, respectively.

The gas phase data for SO_2 capture and for mercury capture across the pilot wet FGD absorber were also used to calculate an expected amount of mercury captured per gram of byproduct gypsum formed. The gas phase SO_2 capture data have not been reported in this report, but averaged approximately 300 ppmv at the FGD inlet and about 30 ppmv or less at the outlet (90+% SO_2 capture). These calculations show an expected amount of 7.2 µg of mercury captured per gram of gypsum byproduct.

Thus, the value calculated from gas-phase data is bracketed by the FGD slurry sample analysis results, using the low and high measured liquor mercury concentrations. Within the limitations imposed by the inability to accurately measure the FGD liquor mercury concentrations, these calculations show good mercury balance closure for the gold catalysts longer-term (30+ hour) wet FGD pilot test.

Table 9 summarizes coal sample analyses for mercury and halogen species concentrations. Each day, both the PRB and lignite fired were sampled and analyzed individually. It was not possible to collect a representative sample of the blend actually fired each day, nor was it possible to

accurately track what blend percentage was being fired at any given time. The results in Table 9 show that the lignite had considerably higher mercury concentration than the PRB coal, with a 0.30 μg/g average mercury content for the lignite versus 0.11 μg/g for the PRB. Also, the PRB has a higher heat content than the lignite (not shown in the table), so the differences in mercury content would be even greater if expressed on the basis of mass per Btu. It is apparent from the large difference in mercury concentration between the two fuels why the flue gas mercury concentration can vary significantly during the day, since the percentage of each fired at any one time is not specifically controlled.

The lignite also tended to average more chloride (54 ppm) and fluoride (57 ppm) content than the PRB (22 and 44 ppm, respectively). Both fuels tended to have more fluoride than chloride content, which is not unusual for low-rank western coals. Neither had measurable bromide or iodide concentrations.

Table 10 summarizes the results of loss on ignition (LOI) and mercury concentration analyses of ash samples collected from a first-row ESP hopper on Unit 3 during these tests. The results are as expected: little LOI in the samples (0.3 wt% average) and correspondingly little adsorbed mercury (0.13 ppm average).

Flue Gas Characterization Results

During the oxidation catalyst activity and pilot wet FGD tests conducted during April, extensive flue gas characterization efforts were also made at Monticello. This flue gas characterization included 1). SO_3/sulfuric acid concentrations at the catalyst inlet and outlets; 2). flue gas halogen concentrations at the catalyst pilot inlet; 3). flue gas trace metals concentrations at the catalyst pilot inlet; and 4). mercury SCEM relative accuracy tests by the Ontario Hydro method at the catalyst pilot inlet, catalyst outlets, and pilot wet FGD outlet.

Flue Gas SO_3/Sulfuric Acid Concentration Measurements

Measurements were made by the Controlled Condensation Method to determine whether the mercury oxidation catalysts also oxidized a percentage of the flue gas SO_2 to SO_3/sulfuric acid. The tests were conducted by sampling the catalyst pilot unit inlet gas and the outlet gas from two of the four catalysts on two separate days. The results are summarized in Table 12.

The results show no evidence of SO_2 oxidation across the catalysts. In fact, it appears that SO_3/sulfuric acid is being adsorbed by the catalysts. The inlet SO_3 concentrations averaged 1 to 2 ppmv (dry basis) while the outlet concentrations were measured at 0.1 to 0.4 ppmv. Adsorption of SO_3/sulfuric acid by the catalyst may contribute to a loss of catalyst activity over time due to the blocking of active catalyst sites.

Table 12. Summary of Flue Gas Sulfuric Acid Concentration Measurements

Location	Sample ID	Date	H_2SO_4 (ppmv dry basis)
Catalyst Inlet	Run 1	4/8/2005	3.8
Catalyst Inlet	Run 2	4/8/2005	1.3
Catalyst Inlet	Run 3	4/8/2005	0.6
Catalyst Inlet Average			**1.9**
J-M Pd	Run 1	4/8/2005	0.1
J-M Pd	Run 2	4/8/2005	0.1
J-M Pd	Run 3	4/8/2005	0.1
J-M Pd Catalyst Outlet Average			**0.1**
SCR Catalyst	Run 1	4/8/2005	0.4
SCR Catalyst	Run 2	4/8/2005	0.3
SCR Catalyst	Run 3	4/8/2005	0.4
SCR Catalyst Outlet Average			**0.4**
Catalyst Inlet	Run 1	4/19/2005	0.5
Catalyst Inlet	Run 2	4/19/2005	1.2
Catalyst Inlet	Run 3	4/19/2005	1.3
Catalyst Inlet Average			**1.0**
Gold Catalyst	Run 1	4/19/2005	0.1
Gold Catalyst	Run 2	4/19/2005	0.1
Gold Catalyst	Run 3	4/19/2005	0.1
Gold Catalyst Outlet Average			**0.1**
Regenerated Pd	Run 1	4/19/2005	0.1
Regenerated Pd	Run 2	4/19/2005	0.1
Regenerated Pd	Run 3	4/19/2005	0.1
Regenerated Pd Catalyst Outlet Average			**0.1**

Flue Gas Halogen Species Concentrations

Sampling was conducted by Reference Method 26a to determine the concentrations of halogen species in the flue gas at the catalyst pilot unit inlet, as halogen species are known to participate in elemental mercury oxidation reactions. The results of these measurements are summarized in Table 13. They show that the flue gas contains about 2 ppmv of chloride (most likely as HCl) and 6 to 7 ppmv of fluoride (most likely as HF). Small amounts of bromide (0.04 ppm) and iodide (0.15 ppm) were also measured, again most likely as the acids of these halides.

Chlorine (Cl_2) concentrations could not be measured because of chloride contamination of the reagent used for the impinger solutions, which was discovered after the fact when reagent blank samples were analyzed. Concentrations of fluorine (F_2), bromine (Br_2), and iodine (I_2) were all below analytical detection limits, as shown in the table.

Table 13. Results of Flue Gas Halogen Sampling by Method 26a (Catalyst Inlet, 4/5/05)

Sample ID	Sample Start Time	Vol% Water in Gas	Chloride (ppm)	Cl_2 (ppb)*	Fluoride (ppm)	F_2 (ppb)	Bromide (ppm)	Br_2 (ppb)	Iodide (ppm)	I_2 (ppb)
Run 1	15:18	11.4	1.59	-	5.90	<153	0.04	<36	0.14	<69
Run 2	16:34	12.0	1.70	-	7.18	<154	0.04	<37	0.16	<57
Run 3	17:57	12.1	1.90	-	7.79	<153	0.04	<36	0.16	<69
Average	-	11.8	1.73	-	6.96	<153	0.04	<36	0.15	<65

*Cl_2 concentrations could not be measured because of chloride contamination of the impinger solution reagent

Flue Gas Trace Metals Concentrations

Flue gas metals concentrations were measured by Reference Method 29 at the catalyst pilot unit inlet location. These measurements were made to determine what metals are present in the vapor phase that could potentially be catalyst poisons, although the method also determines particulate-phase metals concentrations. The results of these measurements are summarized in Table 14. The particulate phase results are expressed in the table as an equivalent gas-phase concentration in ppbv (dry basis).

The results in Table 14 show that selenium is the metal present in the highest concentration in the vapor phase, followed by copper, arsenic and chromium, in order (mercury concentrations were not quantified by Method 29 in these measurements). Selenium is a suspected mercury oxidation catalyst poison, and arsenic is a known poison for SCR catalysts.

Mercury SCEM Relative Accuracy Tests by the Ontario Hydro Method

The Ontario Hydro method was employed to conduct relative accuracy tests to validate the Hg SCEM results that are being used to track oxidation catalyst activity over time. The Ontario Hydro measurements were made by simultaneously sampling the oxidation catalyst pilot unit inlet, catalyst outlet, and wet FGD pilot unit outlet flue gas during the second day of the two-day wet FGD pilot tests conducted downstream of each catalyst. Ontario Hydro measurements were also conducted during baseline (no catalyst) wet FGD pilot tests.

Table 15 summarizes the results of the relative accuracy tests conducted across the oxidation catalysts. The corresponding results for relative accuracy tests conducted across the wet FGD pilot unit are discussed later in this subsection.

As was reported previously in Table 2, the flue gas total and elemental mercury concentrations varied considerably from day to day in the results presented in Table 15, more so in the Ontario Hydro results than was shown in the SCEM results. As measured by the Ontario Hydro method, the catalyst pilot unit inlet total mercury concentrations varied from 17 to 31 $\mu g/Nm^3$, a factor of nearly two, while the inlet elemental mercury concentrations varied from 10 to 19 $\mu g/Nm^3$, also nearly a factor of two.

Table 14. Results of Flue Gas Method 29 Measurements (Catalyst Inlet, 4/6/05)

Sample ID	Units	Run 1	Run 2	Run 3	Average
Sample Start Time		11:35	13:26	15:45	
Moisture in Flue Gas	Vol %	11.4	11.5	11.6	11.5
Gas Phase Results:					
Antimony	(ppbv) dry	0.002	<0.002	<0.002	<0.002
Arsenic	(ppbv) dry	0.36	0.41	<0.04	0.27
Barium	(ppbv) dry	0.06	0.07	0.09	0.07
Beryllium	(ppbv) dry	ND	ND	ND	ND
Cadmium	(ppbv) dry	<0.01	<0.00	<0.01	<0.01
Chromium	(ppbv) dry	0.28	0.20	0.15	0.21
Cobalt	(ppbv) dry	0.07	<0.01	0.02	0.03
Copper	(ppbv) dry	2.26	2.56	2.56	2.56
Lead	(ppbv) dry	<0.01	<0.01	<0.00	<0.01
Nickel	(ppbv) dry	0.09	0.23	0.04	0.12
Selenium	(ppbv) dry	22.9	23.9	5.24	17.4
Thallium	(ppbv) dry	ND	ND	ND	ND
Zinc	(ppbv) dry	<2.01	<1.86	<1.63	<1.83
Particulate Phase Results:					
Antimony	(ppbv) dry	0.18	0.11	0.18	0.16
Arsenic	(ppbv) dry	0.71	0.52	1.71	0.98
Barium	(ppbv) dry	53.9	35.4	40.8	43.3
Beryllium	(ppbv) dry	0.07	0.04	0.07	0.06
Cadmium	(ppbv) dry	0.03	0.05	0.03	0.04
Chromium	(ppbv) dry	1.74	0.68	8.26	3.56
Cobalt	(ppbv) dry	0.38	0.23	2.29	0.97
Copper	(ppbv) dry	1.35	0.89	3.18	1.81
Lead	(ppbv) dry	0.99	0.58	2.68	1.42
Nickel	(ppbv) dry	0.14	0.11	0.07	0.10
Selenium	(ppbv) dry	0.91	1.46	31.5	11.3
Thallium	(ppbv) dry	ND	ND	ND	ND
Zinc	(ppbv) dry	1.51	1.23	4.70	2.48

Table 15. April 2005 Ontario Hydro Relative Accuracy Results for Monticello Pilot (mean and standard deviation of three runs compared to simultaneous Hg SCEM results)

	Total*	Elemental*	Oxidized*
SCR Catalyst, April 7, 2005			
Catalyst Inlet – OH, μg/Nm^3*	20.2 ± 4.3	10.9 ± 3.6	9.3 ± 1.0
Catalyst Inlet - SCEM, μg/Nm^3	29.7 ± 4.2	15.5 ± 0.4	14.2 (± 3.8 est.)
Relative Accuracy, % (based on means)	147	142	153
Catalyst Outlet – OH, μg/Nm^3	27.1 ± 1.4	2.4 ± 0.5	24.7 ± 0.9
Catalyst Outlet - SCEM, μg/Nm^3	23.1 ± 6.0	11.0 ± 1.4	12.1 (± 4.6 est.)
Relative Accuracy, % (based on means)	85	460	49
Observed Hg^0 Oxidation Across Catalyst, % by OH	-	78	-
Observed Hg^0 Oxidation Across Catalyst, % by SCEM	-	29	-
Regenerated Pd, April 9, 2005			
Catalyst Inlet - OH, μg/Nm^3	17.4 ± 5.6	10.3 ± 5.7	7.1 ± 0.2
Catalyst Inlet - SCEM, μg/Nm^3	32.9 ± 3.4	21.5 ± 3.5	11.4 (± 0.1 est.)
Relative Accuracy, % (based on means)	189	209	160
Catalyst Outlet – OH, μg/Nm^3	23.7 ± 3.6	2.2 ± 0.8	21.5 ± 3.8
Catalyst Outlet - SCEM, μg/Nm^3	31.6 ± 2.8	5.0 ± 0.4	26.6 (± 2.4 est.)
Relative Accuracy, % (based on means)	133	230	124
Observed Hg^0 Oxidation Across Catalyst, % by OH	-	79	-
Observed Hg^0 Oxidation Across Catalyst, % by SCEM	-	77	-
J-M Pd, April 18, 2005			
Catalyst Inlet – OH, μg/Nm^3	22.2 ± 1.5	16.1 ± 0.8	6.1 ± 0.7
Catalyst Inlet - SCEM, μg/Nm^3	28.6 ± 3.0	13.4 ± 0.9	15.2 (± 2.1 est.)
Relative Accuracy, % (based on means)	129	83	250
Catalyst Outlet – OH, μg/Nm^3	21.1 ± 1.9	2.7 ± 0.2	18.4 ± 1.7
Catalyst Outlet - SCEM, μg/Nm^3	28.8 ± 3.9	7.9 ± 3.1	20.9 (± 0.8 est.)
Relative Accuracy, % (based on means)	136	290	114
Observed Hg^0 Oxidation Across Catalyst, % by OH	-	83	-
Observed Hg^0 Oxidation Across Catalyst, % by SCEM	-	41	-
Gold Catalyst, April 20, 2005			
Catalyst Inlet – OH, μg/Nm^3	30.8 ± 1.5	19.4 ± 0.1	11.4 ± 1.6
Catalyst Inlet - SCEM, μg/Nm^3	33.3 ± 2.8	21.4 ± 4.7	11.9 (± 1.9 est.)
Relative Accuracy, % (based on means)	108	110	104
Catalyst Outlet – OH, μg/Nm^3	29.4 ± 2.5	1.10 ± 0.24	28.3 ± 2.2
Catalyst Outlet - SCEM, μg/Nm^3	31.7 ± 3.1	1.50 ± 0.52	30.2 (± 2.6 est.)
Relative Accuracy, % (based on means)	108	136	107
Observed Hg^0 Oxidation Across Catalyst, % by OH	-	94	-
Observed Hg^0 Oxidation Across Catalyst, % by SCEM	-	93	-

*****Note – All concentrations corrected to 3% O_2, dry basis; 1 μg/Nm^3 at 3% O_2 equals 0.67 lb/10^{12} Btu heat input

Because of the observed variability in concentrations, the table shows the mean value for three Ontario Hydro runs as well as the standard deviation about the mean. The magnitude of the standard deviation can be compared to the mean value to provide a measure of the variability of

the measurements. The larger the standard deviation relative to the mean value, the more variable were the measurement results. This variability could be due to changes in the actual flue gas concentrations over time, variability within the measurement methods, or both.

Since the Hg SCEM measurements were made with only one analyzer, this meant that four measurements had to be made (catalyst inlet and outlet, total and elemental mercury) while the two Ontario Hydro trains (catalyst inlet and outlet) completed the three runs. Thus, the Hg SCEM data for each of the four measurements represent a total of one to two hours of data collected during the Ontario Hydro run period (approximately 8 hours) while the Ontario Hydro results represent integrated samples collected over three two-hour runs. With the observed variability in mercury total concentration and speciation in the catalyst inlet flue gas at Monticello, it is possible that much of any disagreement between the Ontario Hydro and SCEM results can be due to differences in averaging time periods for the two methods.

Standard deviation values are also shown for the Hg SCEM data. For the total and elemental mercury concentrations, the mean values are calculated from a number of short-term average measurements (e.g., 10 to 20 measurements of 3- to 4-minute averages) whereas the Ontario Hydro data each represent three, two-hour-average measurements. Oxidized mercury concentrations are measured by the difference between total and elemental mercury with the Hg SCEM, and one SCEM was used to measure both the catalyst inlet and catalyst outlet locations. This meant the oxidized mercury concentrations could only be calculated from averages, not from individual data points. Thus, standard deviations cannot be calculated directly for oxidized mercury concentrations from the SCEM data. Standard deviations were estimated for Table 6 from the standard deviations of the total and elemental mercury concentration data used to calculate the mean oxidized mercury concentrations.

Comparing the Ontario Hydro method results to Hg SCEM results, the SCEM values for total mercury at the catalyst inlet were higher than the Ontario Hydro results for all four test days. As mentioned above, at least part of this discrepancy may be due to differences in averaging periods between the two methods. The high standard deviations for the means, particularly for April 7 (SCR catalyst) and April 9 (regenerated Pd catalyst) indicate that the concentrations were quite variable over those measurement days. On April 18 (Johnson Matthey Pd) and April 20 (gold), the standard deviations are lower, and the relative accuracies between the two methods are better (closer to 100%).

For the catalyst outlet total mercury concentrations, the relative accuracies between the two methods are a somewhat better than at the inlet for April 7 and 9, and similar to those at the inlet for April 18 and 20.

For elemental mercury concentrations, the catalyst inlet results for April 7 (SCR catalyst) and April 9 (regenerated Pd catalyst) again show poorer agreement between the two methods than the results for April 18 (Johnson Matthey Pd) and April 20 (gold). This is particularly true for April 9, where the SCEM mean was over twice the mean from the Ontario Hydro measurements, although both means showed high standard deviations that may have contributed to the discrepancy. At the catalyst outlet, the elemental mercury concentration measurements by the SCEM are significantly higher than were measured by the Ontario Hydro method for all but the

April 20 (gold) results, with relative accuracies for the other three catalysts ranging from 230% to 460%. For the SCR catalyst and Johnson Matthey Pd catalyst, this discrepancy meant that the Ontario Hydro results showed significantly higher elemental mercury oxidation across those catalysts than the SCEM results. For the regenerated Pd catalyst, the poor relative accuracy on the inlet elemental mercury concentration (209%), as mentioned above, meant the percent oxidation measured across that catalyst by the two methods was similar.

The Ontario Hydro results suggest that the oxidation performance of three of the four catalysts is similar, ranging from 78 to 83 percent elemental mercury oxidation, with only the gold showing significantly better performance (94%). This is quite a contrast with the SCEM results, which show a marked loss in activity for the SCR and Johnson Matthey catalysts compared to the other two.

Previous results from Coal Creek station[7] showed a similar discrepancy between the results by Ontario Hydro and by SCEM for the SCR catalyst tested there, but good agreement between the methods with the Pd catalyst (the regenerated catalyst being tested at Monticello). In the Coal Creek case, it was thought that it was the Ontario Hydro method results that were biased low (for catalyst outlet elemental concentration) rather than the SCEM results being biased high. However, as discussed below for the wet FGD pilot test results, the current Monticello data call into question the SCEM rather than the Ontario Hydro results.

It remains unclear what would cause the elemental mercury concentrations measured by SCEM to be biased high at the catalyst outlet location. It is possible that an oxidized mercury species is formed across the catalysts that captures at a different efficiencies in the Ontario Hydro impinger train than in the SCEM train, and that the species formed may vary with catalyst type.

Ontario Hydro method relative accuracy tests were also conducted for the limestone reagent pilot wet FGD tests conducted downstream of the catalysts. The results of these Ontario Hydro measurements are compared to the Hg SCEM results in Table 16. Also included in the table are results from a baseline test conducted with the wet FGD pilot unit, where flue gas from the catalyst pilot unit inlet rather than the outlet from one of the catalyst modules was treated.

The baseline results in Table 16 show good agreement between the Ontario Hydro and SCEM measurements for the FGD inlet, with relative accuracies ranging from 85% for the elemental mercury concentrations to 99% for oxidized mercury concentrations. However, at the FGD outlet, the relative accuracies do not show good agreement.

The total mercury concentrations measured at the FGD outlet show a relative accuracy of 76% when comparing the SCEM result to the Ontario Hydro result. However, the standard deviations about the mean for both methods are high, suggesting that variability in the measured concentrations during the day may have contributed to the apparent bias between the two method results.

Table 16. April 2005 Ontario Hydro Relative Accuracy Results for Monticello FGD Pilot (mean and standard deviation of three runs compared to simultaneous Hg SCEM results)

	Total Hg	Elemental Hg	Oxidized Hg
Baseline (no catalyst upstream), April 5, 2005			
FGD Inlet - OH, μg/Nm^3	24.9 ± 1.6	16.3 ± 1.4	8.6 ± 0.8
FGD Inlet - SCEM, μg/Nm^3	22.4 ± 1.1	13.9 ± 1.0	8.5 (± 0.1 est.)
Relative Accuracy, % (based on means)	90	85	99
FGD Outlet - OH, μg/Nm^3	16.0 ± 3.4	15.5 ± 3.6	0.48 ± 0.15
FGD Outlet - SCEM, μg/Nm^3	12.1 ± 1.5	9.9 ± 0.6	2.2 (± 0.9 est.)
Relative Accuracy, % (based on means)	76	64	460
Observed Hg Removal Across Wet FGD, % by OH	36	5	94
Observed Hg Removal Across Wet FGD, % by SCEM	46	29	74
SCR Catalyst, April 7, 2005			
FGD Inlet/Catalyst Outlet - OH, μg/Nm^3	27.1 ± 1.4	2.4 ± 0.5	24.7 ± 0.9
FGD Inlet/Catalyst Outlet - SCEM, μg/Nm^3	23.1 ± 6.0	11.0 ± 1.4	12.1 (± 4.6 est.)
Relative Accuracy, % (based on means)	85	460	49
FGD Outlet - OH, μg/Nm^3	3.6 ± 1.5	2.1 ± 1.5	1.50 ± 0.02
FGD Outlet - SCEM, μg/Nm^3	6.4 ± 1.0	4.5 ± 0.5	1.86 (± 0.5 est.)
Relative Accuracy, % (based on means)	180	210	124
Observed Hg Removal Across Wet FGD, % by OH	87	14	94
Observed Hg Removal Across Wet FGD, % by SCEM	72	59	85
Regenerated Pd, April 9, 2005			
FGD Inlet/Catalyst Outlet - OH, μg/Nm^3	23.7 ± 3.6	2.2 ± 0.8	21.5 ± 3.8
FGD Inlet/Catalyst Outlet - SCEM, μg/Nm^3	31.6 ± 2.8	5.0 ± 0.4	26.6 (± 2.4 est.)
Relative Accuracy, % (based on means)	130	230	124
FGD Outlet - OH, μg/Nm^3	7.9 ± 1.0	6.2 ± 0.8	1.71 ± 0.90
FGD Outlet - SCEM, μg/Nm^3	8.6 ± 3.5	3.4 ± 0.5	5.2 (± 3.0 est.)
Relative Accuracy, % (based on means)	110	55	300
Observed Hg Removal Across Wet FGD, % by OH	67	-187	92
Observed Hg Removal Across Wet FGD, % by SCEM	73	31	81
J-M Pd, April 18, 2005			
FGD Inlet/Catalyst Outlet - OH, μg/Nm^3	21.1 ± 1.9	2.7 ± 0.2	18.4 ± 1.7
FGD Inlet/Catalyst Outlet - SCEM, μg/Nm^3	28.8 ± 3.9	7.9 ± 3.1	20.9 (± 0.8 est.)
Relative Accuracy, % (based on means)	136	290	114
FGD Outlet - OH, μg/Nm^3	4.4 ± 0.3	3.9 ± 0.3	0.55 ± 0.04
FGD Outlet - SCEM, μg/Nm^3	4.6 ± 0.4	2.4 ± 0.5	2.2 (± 0.1 est.)
Relative Accuracy, % (based on means)	105	62	400
Observed Hg Removal Across Wet FGD, % by OH	79	-44	97
Observed Hg Removal Across Wet FGD, % by SCEM	84	70	89

Table 16 (continued)

	Total Hg	Elemental Hg	Oxidized Hg
Gold Catalyst, April 20, 2005			
FGD Inlet/Catalyst Outlet - OH, μg/Nm^3	29.4 ± 2.5	1.10 ± 0.24	28.3 ± 2.3
FGD Inlet/Catalyst Outlet - SCEM, μg/Nm^3	31.7 ± 3.1	1.50 ± 0.52	30.2 (± 2.6 est.)
Relative Accuracy, % (based on means)	108	136	107
FGD Outlet - OH, μg/Nm^3	7.0 ± 2.7	3.2 ± 1.7	3.8 ± 0.9
FGD Outlet - SCEM, μg/Nm^3	7.7 ± 1.6	2.1 ± 0.6	5.6 (± 1.0 est.)
Relative Accuracy, % (based on means)	110	66	150
Observed Hg Removal Across Wet FGD, % by OH	76	-189	87
Observed Hg Removal Across Wet FGD, % by SCEM	76	-43	81

Note – All concentrations corrected to 3% O_2, dry basis; 1 μg/Nm^3 at 3% O_2 equals 0.67 lb/10^{12} Btu heat input

The mercury speciation data for the FGD outlet clearly show a bias between the two method results. The Ontario Hydro method results show more elemental mercury and less oxidized mercury than the SCEM results at the FGD outlet. The Ontario Hydro results better match expectations for the performance of the pilot wet FGD system operating in limestone forced oxidation mode: relatively high oxidized mercury removal (94%) and little elemental mercury removal (5%). The SCEM results (74% oxidized mercury removal and 29% elemental mercury removal) show evidence of elemental mercury oxidation in the sample collection train, as the oxidized mercury removal appears to be biased low while the elemental mercury removal appears to be biased low.

For the mercury oxidation catalyst outlet FGD test results, the FGD inlet (catalyst outlet) total mercury concentration results agree reasonably well between the two methods, as was discussed earlier for the results presented in Table 15. For the wet FGD outlet total mercury measurements, the results for the regenerated Pd, Johnson Matthey Pd, and gold catalysts show good agreement between the two methods, with relative accuracy ranging from 105 to 110%. However, for the SCR catalyst, the SCEM results show much more total mercury at the FGD outlet than the Ontario Hydro results (a relative accuracy of 180%). The standard deviations about the means for the two measurement methods suggest that at least part of this discrepancy can be attributed to variability in the actual flue gas concentrations during the measurement period, though.

Note that the Ontario Hydro results are internally consistent for the SCR catalyst outlet FGD test. That is, they show a low FGD inlet elemental mercury concentration (2.4 μg/Nm^3) and a correspondingly low outlet total mercury concentration (3.6 μg/Nm^3). The expectation is that the wet FGD system would remove oxidized mercury at a high percentage, and little or no elemental mercury removal. This would make the outlet total mercury concentration slightly higher than the inlet elemental mercury concentration, as seen in the Ontario Hydro results.

The SCEM results for the SCR catalyst test are not as consistent by this comparison. Both the FGD inlet elemental mercury concentration and the FGD outlet total mercury concentration are higher than in the corresponding Ontario Hydro concentrations. However, the FGD outlet total mercury by SCEM is significantly lower than the inlet elemental mercury concentration (6.4 vs. 11 μg/Nm^3). This would require significant elemental mercury capture to achieve; 59% is shown

in the table for the SCEM results. This high a percentage elemental mercury capture is unlikely, which brings the SCEM results into question.

For all catalyst types, the comparison between the Ontario Hydro and SCEM results for elemental mercury concentrations also shows poor agreement. The catalyst outlet/FGD inlet results were previously discussed with the Table 15 results. The FGD outlet results show relative accuracy percentages ranging from 55% (less elemental mercury reported by SCEM) to 210% (more elemental mercury reported by SCEM. The Ontario Hydro results showed elemental mercury re-emissions for three of the four catalyst outlet tests, with only a small percentage elemental mercury capture for the fourth catalyst (SCR, at 14% capture). In contrast, the SCEM data showed re-emissions only from the gold catalyst test, and elemental removal percentages ranging from 31 to 70% for the other three catalyst tests.

The FGD outlet oxidized mercury concentration relative accuracy percentages ranged from 107% to 400%, indicating that the SCEM always showed more oxidized mercury than did the Ontario Hydro results. Furthermore, the Ontario Hydro data showed higher percentage capture of oxidized mercury than did the SCEM data. The oxidized mercury removal percentages ranged from 87% to 97% by the Ontario Hydro method, which is within the expected range (note that the 87% value is known to be biased low by FGD recycle pump cavitation), while the SCEM data showed lower than expected percentages of 81 to 89%.

These results all provide further evidence that the sampling system for the SCEM was oxidizing some elemental mercury. The apparent bias was least for the gold catalyst, which due to its high oxidation activity produced the least amount of elemental mercury in the FGD inlet flue gas.

In summary, the wet FGD data suggest that the Ontario Hydro results provide the more accurate measure of catalyst and downstream wet FGD mercury performance for the SCR and Johnson Matthey palladium catalysts. The two methods agree reasonably well for evaluating the regenerated Pd and gold catalysts and their downstream wet FGD mercury capture. These comparisons are summarized in Table 17 below.

For the SCR catalyst, the Ontario Hydro results show the FGD total mercury capture percentage is a few percentage points lower than the FGD inlet total mercury oxidation, as would be expected if the wet FGD system is removing oxidized mercury at a high percentage and little or no elemental mercury. In contrast, the SCEM results for the SCR catalyst show considerably higher percentage mercury capture in the wet FGD system than would be expected based on the measured inlet total mercury oxidation (highlighted in bold text in the table). The same effect is seen for the Johnson Matthey Pd catalyst: the Ontario Hydro results show an FGD total mercury removal percentage somewhat less than the inlet total mercury oxidation percentage, while the SCEM results show greater total mercury capture than the inlet speciation would lead one to expect. For the other two catalysts, this comparison shows the expected trend of somewhat lower total mercury capture than the inlet total mercury oxidation percentage for both measurement types.

Table 17. Summary of Comparison of Ontario Hydro and SCEM Results for Oxidation Catalyst Performance and Downstream Wet FGD Mercury Capture for April Monticello Results

Catalyst	Measurement Method	Hg^0 Oxidation Across Catalyst, %	Total Hg Oxidation at FGD Inlet, %	Total Hg Capture Across Wet FGD, %
SCR	Ontario Hydro	78	91	87
	SCEM	**29**	**52**	**72**
Regenerated Pd	Ontario Hydro	79	91	67
	SCEM	77	84	73
Johnson Matthey Pd	Ontario Hydro	83	87	79
	SCEM	**41**	**73**	**84**
Gold	Ontario Hydro	94	96	76
	SCEM	93	95	76

Comparison of Pilot Wet FGD and Full-scale Wet FGD Mercury Capture Performance

Ontario Hydro measurements were also made on the outlet flue gas from the full-scale wet FGD system on Monticello Unit 3, on module 3C. There were no corresponding Hg SCEM measurements made there, so there are no relative accuracy data for this location. Also, Ontario Hydro measurements were not made at the full-scale wet FGD inlet, although there were flue gas mercury concentrations measurements made by SCEM at the oxidation catalyst pilot unit inlet that day. Since the oxidation catalyst pilot unit pulls flue gas from the 3C induced draft fan exhaust, the oxidation catalyst pilot unit SCEM results should have been reasonably representative of the module 3C full-scale wet absorber inlet flue gas on that day. The table also shows Ontario Hydro results from the pilot wet FGD system under baseline (no catalyst) operation from the day before.

Table 18. Results of Ontario Hydro Measurements at Monticello Full-scale Module 3C Wet FGD Absorber Outlet Compared to Pilot Wet FGD Results

Sample Location (Sampling Date)	Hg Concentration, µg/Nm³ @ 3% O_2, mean and standard deviation of mean*						Hg Removal Across Wet FGD, %		
	Catalyst Inlet/FGD Inlet			Wet FGD Outlet					
	Total Hg	Hg^0	Hg^{+2}	Total Hg	Hg^0	Hg^{+2}	Total Hg	Hg^0	Hg^{+2}
Wet FGD Pilot Baseline [no catalyst] (4/5)	24.9 ± 1.6	16.3 ± 1.4	8.6 ± 0.8	16.0 ± 3.4	15.5 ± 3.6	0.48 ± 0.15	36	5	94
Full-scale Module 3C (4/6)	30.8 ± 6.1**	21.3 ± 2.1**	9.5 (± 4.0 est.)**	27.9 ± 3.1	27.6 ± 3.1	0.25 ± 0.03	9	-30	97

*1 µg/Nm³ at 3% O_2 equals 0.67 lb/10^{12} Btu heat input

**Measured by Hg SCEM; all other values in table are by Ontario Hydro Method

The results in Table 18 show that both the pilot and full-scale wet FGD systems achieve a high percentage removal of oxidized mercury from the flue gas. For elemental mercury capture, the pilot wet FGD absorber showed a low percentage removal, while the full-scale wet FGD absorber showed evidence of elemental mercury re-emissions. This results in the calculated overall mercury removal percentage being higher for the pilot wet FGD than for the full-scale

absorber. The inlet mercury oxidation percentages were similar for the two days (35% on April 5, when the pilot data were collected, and 31% on April 6), so the percentage mercury capture across the two FGD absorbers would have otherwise been expected to be similar.

However, the full-scale wet FGD removal percentages are calculated from measurements by two different methods, and do not necessarily represent average concentrations over the same time period. Given the observed variability in the measured mean concentrations (as indicated by the relatively high standard deviations about the mean values), it is possible that the full-scale wet FGD re-emissions levels are overstated, and the overall mercury removal percentage is understated.

CONCLUSION

Results to date show that reliable sonic horn operation will be required to prevent fly ash buildup in the horizontal-gas-flow catalysts, particularly the SCR catalyst and the regenerated palladium catalyst. For the gold and Johnson Matthey (new) palladium catalysts, it does not appear that optimum sonic horn operation is as critical.

Catalyst activity test results show that gold is the most active of the four catalysts being tested at Monticello Station. Measurements by mercury SCEM and by the Ontario Hydro method show similar mercury oxidation activity for this catalyst, at approximately 91 to 93% elemental mercury oxidation in April. June results by SCEM show that this activity had decreased to 84%.

The SCEM results rank the regenerated palladium, Johnson Mathey palladium, and the SCR catalysts in decreasing order of mercury oxidation activity. However, Ontario Hydro results from April show that the Johnson Matthey palladium and SCR catalysts are as active as the regenerated palladium.

The results of pilot wet FGD tests conducted during the quarter at Monticello tend to support the Ontario Hydro method rather than the SCEM results. In the SCEM results, the total mercury capture percentage across the wet FGD system was higher than the total mercury oxidation in the pilot wet FGD inlet flue gas for the Johnson Matthey palladium and SCR catalyst tests. This would require significant removal of elemental mercury across the wet FGD to achieve, which is unlikely. The Ontario Hydro results show the expected relationship for these two tests, where the total mercury removal percentage across the wet FGD absorber is slightly lower than the inlet flue gas mercury oxidation percentage.

Mercury SCEM results show that all of the catalysts lost activity for mercury oxidation over the time period from April to June. However, these apparent losses have not been confirmed by Ontario Hydro method measurements. The next planned Ontario Hydro method measurements at this site are to be conducted in the fall of this year.

In general, the pilot wet FGD test results from April show that the oxidation catalysts markedly increased the mercury removal percentage across the wet FGD compared to baseline (no catalyst upstream) operation at Monticello. In the Ontario Hydro method results, the baseline FGD total mercury removal was 36%, which increased to 67% to 87% downstream of the catalysts. The Ontario Hydro results showed that the mercury control performance for the wet FGD downstream of three of the four catalysts was limited by elemental mercury re-emissions. This suggests that overall mercury capture by the wet FGD downstream of mercury oxidation catalysts could be improved by using FGD additives or other approaches to limit mercury re-emissions.

The analytical results from pilot wet FGD operation downstream of the catalysts at Monticello show that much of the mercury removed by the wet FGD was found in the FGD liquor rather than the byproduct solids (approximately 40% to 80% of the total mercury in the slurry was found in the liquor). However, determination of this percentage was made difficult due to an apparent interfering species in the FGD liquor mercury analyses. Notwithstanding the liquor

mercury concentration measurement difficulties, these results show a high percentage of scrubbed mercury in the liquor rather than byproduct solids compared to what URS has measured in other U.S. FGD systems.

Flue gas characterization results show that the flue gas at the catalyst pilot unit contains low average concentrations of HCl (2 ppm) and HF (7 ppm), as was expected for the western, low-halogen content fuels fired there. The characterization results also show that the mercury oxidation catalysts do not oxidize flue gas SO_2 to form SO_3/sulfuric acid, but instead may adsorb SO_3/sulfuric acid from the inlet gas. Results from measurements by Method 29 show that the flue gas contains relatively high concentrations of selenium. Adsorption of both SO_3 and/or selenium on catalyst surfaces may promote a loss of catalyst activity over time.

Coal samples collected from Monticello Unit 3 show that the Texas lignite and PRB coals have markedly different mercury contents. This helps explain the observed variability of total mercury concentrations and mercury speciation in the catalyst pilot unit.

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